Assessment of whole-grain flour quality for confectionery use

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Abstract

Introduction. The aim of the research was to determine the quality indicators of whole grain millet flour for use in the technology of cookies from viscous-plastic dough.

Materials and methods. Millet whole grain flour (wheat, spelt, barley, amaranth, buckwheat) and enzymes – fungal glucoamylase and cellulase were used. The moisture content in the flour was determined by the thermogravimetric method, whiteness by a photoelectric device, total acidity by titration, ash content by the accelerated method, coarseness by a laboratory scatterer, gluten was evaluated by content, extensibility, elasticity, resistance to deforming load. The morphology of starch granules was examined using an electron microscope, flour color was measured with a colorimeter, and sugar accumulation was determined by the iodometric method.

Results and discussion. Whole-grain millet flour differed from high-grade wheat flour in appearance, taste, smell, and color. It was found that spelt and barley flours were the lightest in color, while wheat and amaranth flours were the darkest.

The granulometric composition of millet flour was heterogeneous, with particles of varying sizes. The main fraction of each flour type exceeded the particle size of high-grade wheat flour: amaranth and wheat – 200–150 microns; buckwheat and barley – >200 microns and 132–150 microns, respectively; spelt – >200–150 microns. It was found that the gluten complex was formed only in whole grain wheat and spelt flour. The amount of gluten in them was lower compared to high-grade wheat flour by 34.5 and 24.5%, respectively. According to the gluten deformation index, wheat flour belonged to group I, but had 10% less extensibility, spelt flour – to group II with extensibility 6.7% greater than wheat. In barley, buckwheat and amaranth flour, the gluten framework was not formed.

Each type of flour had a characteristic structure of starch grains: small ones – in amaranth and barley, large polygonal ones – in green buckwheat flour, medium ones – round or oval ones – in wheat and spelt. Dough with whole grain millet flour did not form a viscous-plastic structure sufficient for cookies.

Conclusions. When using whole-grain millet flour, the combined application of glucoamylase and cellulase was recommended, as it increased the content of water-soluble compounds and improved the viscous-plastic consistency of the cookie dough.

Introduction

One of the key requirements in cookie production is the quality of the flour, as it directly influences the structural and mechanical properties of the dough, the consistency and appearance of the cookies, and also determines the parameters for dough mixing and shaping (Boz, 2019).

The main type of flour used in cookie technology is high grade wheat flour, less often – first, second grade (Emem et al., 2024). As an alternative, for people with dietary requirements, as well as to increase the nutritional value of the finished product, pumpkin (Stabnikova et al., 2023), rice, buckwheat, amaranth, barley, corn and other types can be used (Ivanov et al., 2021). Highgrade flour has a light color, low ash content (0.5 – 0.55%) and a small amount of highly dispersed grain shell particles. Dough from this flour had delicate texture and a pleasant taste (Dziki et al., 2024). Non-traditional types of flour have specific sensory characteristics inherent in natural grain, as well as a higher content of shell particles. The absence of gluten protein fraction or the inability to form a complete gluten complex significantly affected the structure of the finished product (Xu et al., 2020). Technological tasks in such cases included the selection of structure-forming agents to form a complete coagulation structure of the dough or limiting the recipe dosage of non-traditional types of flour to an acceptable level of quality of dough and finished products (Poiana et al., 2023).

In the production of butter and sugar cookies, the technological process is aimed at forming a coagulation–crystallization structure with plastic-viscous properties. Therefore, dough mixing is carried out in a way that prevents the development of a gluten network, highlighting the inefficient use of wheat flour and supporting the search for alternative flour sources (Ferradji et al., 2024).

For the production of cookies with plastic-viscous characteristics of the dough and in line with modern trends in healthy nutrition, it is advisable to use whole grain flour from various grain crops. The natural vitamin and mineral complexes, as well as the carbohydrate–amylase and protein-proteinase systems present in such flour, offer optimal physiological availability (Khan et al., 2024).

Regulation of the dough structure based on whole grain flour in order to simplify the technological stages of kneading and shaping, ensuring high quality of the finished product is advisable to carry out by introducing enzyme preparations of a directed spectrum of action (Chowdhury et al., 2024).

The issue of studying the quality of whole grain millet flour in the technologies of flour confectionery products was not studied enough. The baking properties of whole grain wheat flour from black wheat showed that the raw gluten content in it was 23.5% of the I quality group, light brown in color with an acidity of 2.6 °H (Zhygunov et al., 2019). The flour residue when sifting on sieve with holes 670 microns was 4%, the residue on sieve with holes 380 microns was 60%. To improve the quality of flour products, it was recommended to use additives and enzymes (Gómez et al., 2020).

The need to use wheat and rye starters was proved, which caused molecular degradation of arabinoxylan with a decrease in its mass and the formation of a more heterogeneous fine dough structure (Kulathunga et al., 2024). To enhance the quality of bakery products, several biotechnological approaches have been employed. Fermentation with lactic acid bacteria has been used to improve the bioavailability of biologically active compounds in whole-grain wheat flour (Islam et al., 2024). Fermentation with yeasts of the genera *Pichia kudriavzevii*, *Saccharomyces cerevisiae*, *Pichia fermentans*, and *Kluyveromyces marxianus*, along with lactic acid bacteria such as *Lactiplantibacillus plantarum* and *Lacticaseibacillus paracasei*, has been shown to reduce phytic acid content (Qvirist et al., 2024). Additionally, the incorporation of peroxidase into whole-wheat flour has been reported to improve the quality of the resulting products (Hemalatha and Rao, 2024). It was proven that the digestibility of bread improved when using whole grain flour of different dispersion (Jiang et al., 2024), and the glycemic load on the human body reduced when eating bread with the addition of whole grain flour (Jiang et al., 2024).

It was found that the antioxidant activity of whole wheat flour decreased during storage at different temperatures (−20 °C, 4 °C, and 20 °C), with a more pronounced decline observed at higher temperatures (60 °C) during the first 15 days (Kumar et al., 2024). Additionally, it was shown that whole-grain products such as chapatis retained more antioxidant activity than refined products such as pasta.

Processing whole-grain flour into chapatis resulted in a 30% reduction in antioxidant activity, whereas processing it into pasta led to a 70% reduction. The antioxidant properties of whole wheat flour bread enriched with *Celosia argentea* seed flour were evaluated, along with its antidiabetic potential and phytochemicals (Azeez et al., 2024). Bread crumb was characterized by total flavonoid content (0.61–0.85 mg/g), total phenolic content (1.1–1.31 gallic acid equivalents per gram (mg GAE/g), total antioxidant capacity (1.19–3.34 mg GAE/g), iron-reducing antioxidant capacity (0.13–0.54 mg/g) and DPPH (2,2-diphenyl-1-picrylhydrazyl) (42.58–49.75%). The IC50 values obtained for wheat bread substituted with *Celosia argentea* seeds ranged from 58.20 to 171.05 µg/ml.

Antioxidant properties and α-amylase inhibition showed an increase with increasing percentage of *Celosiae argentea* seed inclusion. Biologically active compounds detected in bread prepared by enriching wheat flour (whole grain and refined) with *Celosia argentea* seed flour included 9,12-octadecadienoic acid methyl ester, docosanoic acid methyl ester, E,E,Z-1,3,12-nonadecatriene-5,14-diol, linoleic acid ethyl ester and squalene. Differences in whole-grain wheat flour from various growing regions were observed in the content of phenolic compounds, carotenoids, and antioxidant activity (Kim et al., 2024).

Thus, the analysis made it possible to determine that the use of whole grain flour in flour product formulations is a relevant issue, the study of which has recently received increasing attention. However, most of the existing research is devoted to the assessment of the baking properties of flour, mainly whole grain wheat flour. Information on the possibilities of its use for cookies, as well as the analysis of the technological capabilities of whole grain flour from other cereals, is quite limited.

Therefore, the aim of the research was to determine the quality indicators of whole grain millet flour for use in the technology of cookies from viscous-plastic dough.

Materials and methods

Materials

The following materials were used in the study: whole grain millet flour from wheat, spelt, barley, amaranth, and green buckwheat (Zemledar, Ukraine). To improve the dough structure, enzyme preparations– fungal glucoamylase Omnszym 31022 and fungal cellulase Alphamalt C 21032 (Mühlenchemie, Germany) were used.

Methods

Moisture content in flour

The moisture content in flour was determined by the thermogravimetric method of accelerated drying in a drying cabinet (Hetman et al., 2021). 5 g of the test sample was weighed into two pre-dried and weighed boxes, dried in an electric drying oven at a temperature of 130 °C for 40 min, cooled, weighed and the mass fraction of moisture was calculated using formula:

$$W = \frac{m_1 - m_2}{m} \times 100\%,$$

where m is the mass of the flour sample before drying; m_1 is the mass of the box with the sample before drying; m_2 is the mass of the box with the sample after drying.

Whiteness of flour

The whiteness of the flour was assessed using a photoelectric device (Zhang et al., 2025). The essence of the method is to measure the reflectivity of the compacted-smoothed surface of the flour.

For analysis, two samples weighing 50±5 g were taken from different places of the average flour sample and filled into two cuvettes through a special sieve. The flour in the cuvette was slightly compacted, leveled over the entire surface, and the excess was removed. The photoelectric head of the device was slowly lowered onto the flour and readings were taken using a digital indicator with an accuracy of 0.1 unit of the conventional scale of the device.

Total acidity of flour

Total acidity was determined by titration of a flour suspension of 5 g of flour and 50 ml of distilled water with a 0.1 mol/l alkali solution of KOH or NaOH (Shevchenko, 2018).

Ash content in flour

The ash content in flour was determined by an accelerated method by burning a sample with an accelerator $Mg(CH_3COO)_2$ (Czaja et al., 2020).

Flour particles size

The size of the flour particles was determined using a laboratory disperser with an oscillation frequency of 180–200 min^{-1}, and a set of sieves for determining the size and mass fraction of flour particles. Sieves designed for different types of flour were used with holes 750, 670, 200, 150, and 132 microns (Shevchenko et al., 2022).

Gluten quantity and quality

The raw gluten content and its quality were determined in dough from a 25 g flour sample and 14 ml water after 20 min of exposure. To determine extensibility, elasticity, and resistance to deforming load, 4 g gluten samples were rolled into balls and immersed in water at a temperature of 18–20°C for 15 min.

The elasticity of gluten was assessed by the speed of recovery of the initial length of the gluten ball after stretching for a distance of about 2 cm. By the degree and speed of recovery of the initial length, elasticity was assessed as: good – gluten stretched quite strongly with mandatory almost complete recovery of the shape; unsatisfactory – did not recover at all, with partial ruptures of individual layers and after removing the force quickly compresses (elastic, inelastic); satisfactory elasticity – an intermediate position between good and unsatisfactory.

The extensibility of gluten was assessed over a ruler according to the following gradation: short – up to 10 cm, medium – 10–20 cm, long – more than 20 cm. The resistance of gluten to compressive deformation load was determined on the gluten deformation index device (Shevchenko, 2023).

Shape of starch grains in flour

The determination of the shape of starch grains was assessed visually, using an electron microscope (Red'ko et al., 2021) at a magnification of 10x10. To prepare the test sample, the flour suspension was applied to a glass slide, stained with iodine solution, a coverslip was placed on top and fixed on the microscope.

Flour color

The color of the flour was determined on a Konica Minolta CR-400 colorimeter (Japan) in CIELab Cartesian coordinates, where L* denoted lightness (from 0 – black to 100 – white), a* and b* represented opposite color coordinates, varying from – 50 to +50. In this case, negative a* was green, and positive a* was red, while negative b* was blue, and positive b* was yellow. The parameters were calibrated against a standard white porcelain with a measuring area of 8 mm in diameter, an observation angle of 10° and a D65 light source with a mirror component included (Paquet-Durand et al., 2012).

Accumulation of sugars in the dough

The quality of enzymatic processes under the influence of hydrolases was assessed by the accumulation of sugars in the dough, in terms of glucose. For this purpose, dough was kneaded from a 25 g of flour, an enzyme preparation of fungal glucoamylase or fungal cellulase, or their complex, and 14 ml of water, and the dough was left for fermentation for 360 min in a thermostat at a temperature of 32±°C.

During fermentation, dough samples were taken and the accumulated glucose was quantitatively determined by the iodometric method. Glucoamylase was introduced at the rate of 12.5 g per 100 kg of flour, cellulase – 20 g per 100 kg of flour. When glucoamylase and cellulase were simultaneously introduced, the same calculated amounts were used (Shevchenko et al., 2021).

Statistical analysis

The statistical processing of the results was performed by sequential regression analysis using the Microsoft Excel XP and Origin Pro8 software calculating correlation coefficients (Hinkle et al., 2003).

Results and discussion

The quality indicators of products are mainly influenced by the properties of the raw materials. The characteristics of millet whole grain wheat flour, spelt, barley, amaranth, and green buckwheat flour were determined and are presented in Table 1.

Table 1

Sensory characteristics of whole grain flour

Indicator	High grade wheat flour	Whole grain wheat flour	Whole grain spelt flour	Whole grain barley flour	Whole grain amaranth flour	Whole grain green buckwheat flour
Appearance	Homogeneous powdery mass, without lumps	Homogeneous powdery mass, without lumps, visible particles of grain shells were present				
Color	Light cream	Light gray with shades of light brown	Light cream with a gray tint	Light gray with a beige tint	Light yellow with a gray tint	Light gray with a beige tint
Taste and smell	Grain-specific, clean, without foreign tastes and odors					
Moisture content, %	12.20±0.24	12.00±0.21	11.9±0.25	12.00±0.22	9.60±0.20	11.70±0.21
Total acidity, degrees	1.40±0.15	5.10±0.20	5.00±0.18	7.20±0.07	10.80±0.07	6.60±0.05
Ash content, % dry matter	0.55±0.01	1.34±0.03	1.67±0.02	1.00±0.02	1.67±0.02	2.33±0.03
Whiteness, units	59.00±0.5	-43.85±0.5	29.05±0.5	33.00±0.5	-49.20±0.5	5.85±0.50

* Results given as: M±SD (mean±standard deviation) of triplicate trials

According to the evaluation of sensory indicators, all types of flour corresponded to the signs inherent in the original grain. In each type, crushed particles of grain shells were observed. The moisture content for all samples had approximately the same values, with the exception of amaranth flour, in which this indicator was lower. This was due to the low moisture content of the amaranth grain itself and was consistent with the studies (Mykolenko et al., 2020), which found a moisture content of 9.7 – 9.9% for various samples of full-fat amaranth flour. Amaranth flour was also characterized by the highest values of the total acidity indicator among the studied samples (7.7 times higher than wheat flour), which was associated with a high content of peptides and amino acids, fats and fat-like substances, enzymes, and a significant amount of minerals, as indicated in the publication (Stankevych et al., 2021).

Also, quite high values of total acidity were noted for barley flour – 5.1 times higher compared to wheat flour. At the same time, other types of tested flours exceeded the value of the control sample of high grade wheat flour in terms of total acidity (green buckwheat flour – 5.1 times, spelt and whole wheat flour – 3.6 times), which was due to the high content of shell and germ particles, fats and proteins. The ash content of all samples of whole grain flour naturally exceeded the ash content of high grade wheat flour, with the lowest values of the indicator observed for whole barley flour, and the highest values – for green buckwheat flour.

The whiteness indicator, which was determined by the amount of dietary fiber, natural carotenoids, minerals and was associated with the color of the grain, allowed to distinguish the lighter samples – spelt and barley flour, and the darkest – wheat and amaranth flour.

In more detail, the color of flour was determined using a colorimeter (Table 2).

Table 2

Flour color indicators

Samples of four	***L***	***a****	***b****
High grade wheat	94.70±1.50	0.46±0.10	7.62±0.90
Whole grain wheat	79.53±1.20	3.60±0.50	11.37±1.21
Whole grain spelt	91.00±1.15	1.51±0.46	8.98±1.12
Whole grain barley	92.03±1.75	0.94±0.10	7.36±0.84
Whole grain amaranth	80.74±1.10	3.38±0.35	17.03±1.96
Whole grain green buckwheat	87.73±1.50	1.28±0.12	7.41±0.85

* Results given as: M±SD (mean±standard deviation) of triplicate trials

The results correlate with the obtained data on the whiteness of flour (Table 1) and confirm that the lightest among the flour samples were spelt and barley, for which the whiteness index L* was higher than other types, and the darkest were whole wheat and amaranth flour. At the same time, the spectrum of color coordinates a* showed the absence of green shades in all samples, and the presence of red, weakly expressed ones – for whole grain barley, spelt and green buckwheat flour, more intense ones – for wheat and amaranth. The spectrum b* showed pronounced yellow shades of wheat and amaranth whole grain flour, and for barley, green buckwheat flour, spelt – lower values of yellowness, which were closer to high grade wheat flour. Thus, the natural pigmentation of wheat and barley flour was characterized by more saturated yellow-red shades compared to barley, spelt and green buckwheat flour.

The structural and mechanical properties of dough and finished products are significantly affected by the size of flour particles. The results of determining the size are presented in Table 3.

Table 3

Flour particles size

Sieve	**Hole size, microns**	**High grade wheat flour**	**Whole grain wheat flour**	**Whole grain spelt flour**	**Whole grain barley flour**	**Whole grain amaranth flour**	**Whole grain green buckwheat flour**
Residue on sieve, %							
075	750	–	2.55±0.4	0.49±0.08	4.55±0.33	0.95±0.12	0.53±0,1
067	670	–	1.96±0.7	1.75±0.1	7.36±1.18	0.15±0.1	0.58±0,09
41/43	200	–	68.5±1.06	47.51±2.1	57.77±3.99	87.29±4.77	51.07±0,14
27	150	–	0.10±0.1	36.22±1.8	0.41±0.07	0.36±0.07	0.05±0,01
49/52	132	0.4±0.05	11.73±1.37	8.45±0.78	16.54±0.58	12.14±0.11	36.67±1,17
Passage through sieve, %							
49/52	132	99.6±0.05	15.33±1.15	3.25±0.36	12.72±2.12	2.49±0.4	10.3±0,12

* Results given as: M±SD (mean±standard deviation) of triplicate trials

The data presented in the table confirm that whole-grain millet flour exhibits a higher particle size than high-grade wheat flour. At the same time, whole grain barley and wheat flour differed in a higher content of the largest fractions by 11.91% and 4.51%, respectively. Most particles of whole grain amaranth and wheat flour had sizes in the range of 200 – 150 microns. The main fractions of whole grain green buckwheat flour and barley flour were fractions with particle sizes >200 microns, and 132–150 microns. For spelt flour, the degree of grinding varied in the particle sizes range of 150–670 microns. The content of the smallest fraction, corresponding to the passage through a 49/52 sieve and the particle size of high grade wheat flour, was highest in whole grain wheat, barley and green buckwheat flour.

The main component of flour, which is responsible for the formation of the product frame, is gluten. When determining the quantity and quality of gluten (Table 4), it was found that the gluten complex formed only in wheat and spelt flour.

Table 4

Quantity and quality of flour gluten

Indicator	**Type of flour**					
	High grade wheat flour	**Whole grain wheat flour**	**Whole grain spelt flour**	**Whole grain barley flour**	**Whole grain amaranth flour**	**Whole grain green buckwheat flour**
Quantity of gluten, g	24.9±0.3	16.3±0.2	18.8±0.2	Did not washed		
Elasticity	Good			–	–	–
Extensibility, cm	15.0±0.5	13.5±0.5	16.0±0.5	–	–	–
Gluten deformation index, units of device	67.9±5.0	49.4±5.0	82.2±5.0	–	–	–

* Results given as: M±SD (mean±standard deviation) of triplicate trials

At the same time, the amount of washed gluten in whole grain wheat flour was lower compared to high grade wheat flour by 34.5%, and in whole grain spelt flour – by 24.5%. The elasticity of gluten of all samples was characterized as good, but the extensibility and group were different: whole grain wheat flour belonged to group I according to the gluten deformation index, but due to dietary fiber it had 10% less extensibility compared to high grade wheat flour and had a 27% stronger structure. The gluten of spelt flour belonged to group II in terms of quality, was characterized as "satisfactorily weak", its extensibility was higher compared to the gluten of high grade wheat flour by 6.7%.

In other types of millet whole grain flour – barley, buckwheat, amaranth, the gluten framework was not formed, which was consistent with the studies of the authors who used whole grain amaranth and green buckwheat flour as gluten-free types for gluten-free cakes (Kahlon and Chiu, 2014), as well as for gluten-free bread, pasta, crackers and cookies (Khairuddin and Lasekan, 2021). The fractions of proteins insoluble in water, in combination with dietary fiber, decomposed into separate fragments, without forming a continuous structure.

The experimental flour was examined under a microscope to establish the structure of starch grains as the main carbohydrate of the flour (Figure 1).

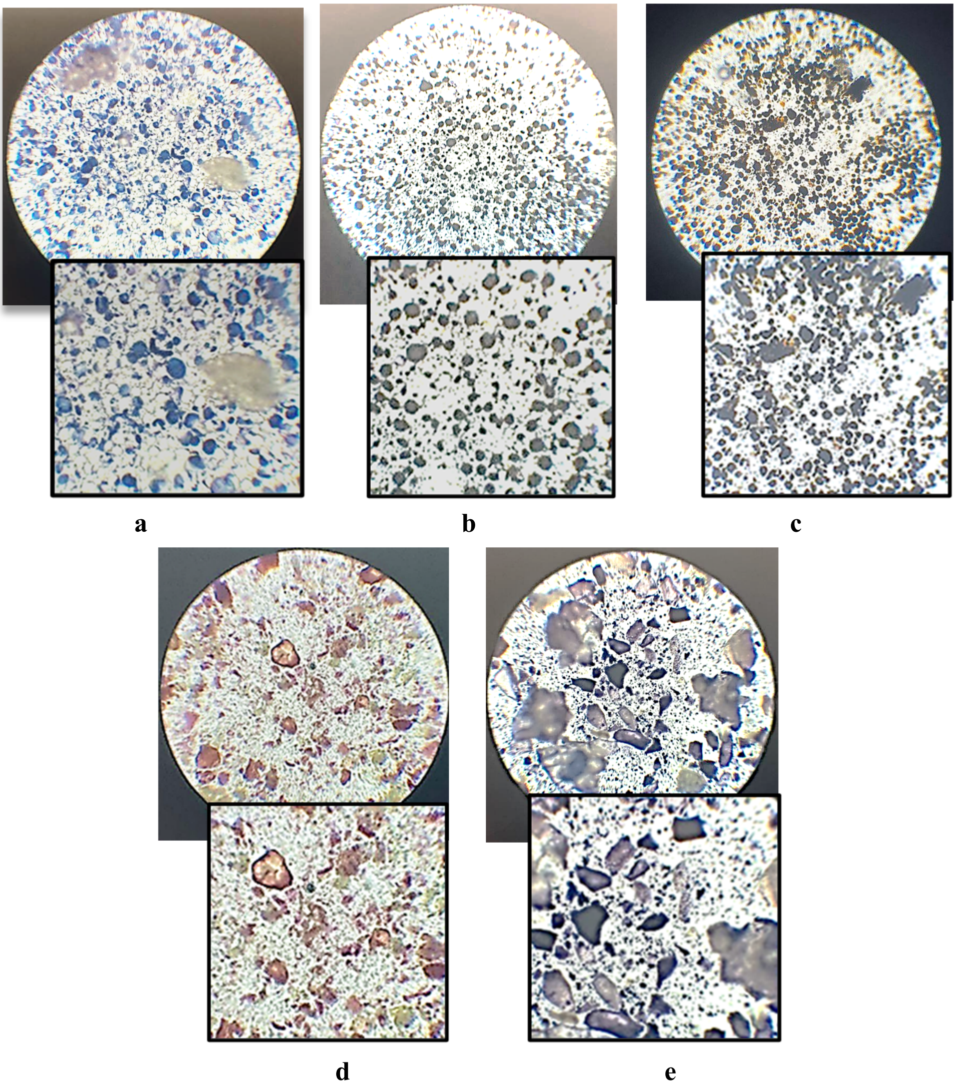

Figure 1. Samples of whole grain millet flour under a microscope:
a – wheat; b – spelt; c – barley; d – amaranth; e – green buckwheat

Microscopy showed that all types of flour had an individual structure of starch grains, determined by the nature of the grain. Amaranth flour had a significant number of small grains with a shiny surface, which alternated with a small number of large grains. Green buckwheat flour was characterized by large starch grains of polygonal shape with a somewhat granular surface. Starch grains of barley flour were generally characterized by small fractions that had a less regular shape. Wheat starch grains were round or oval in shape, medium in size, with clear contours. In spelt flour, starch grains were similar to wheat, but somewhat elongated and thinner.

The selection of rational heat treatment modes for finished products is influenced by the boiling point of the flour suspension. The boiling point of the flour suspension was higher than the gelatinization temperature of pure starch (Figure 2), which was due to the presence of other water-soluble components, including a significant amount of fiber, protein substances, vitamins, minerals. All components of the chemical composition of flour were in close interaction and changed the thermophysical characteristics, including the gelatinization temperature of starch.

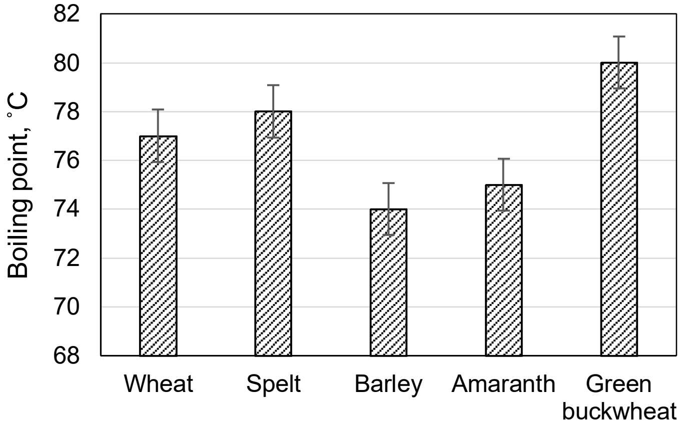

Figure 2. Boiling point of whole grain flour suspensions:
1 – wheat; 2 – spelt; 3 – barley; 4 – amaranth; 5 – green buckwheat

In the dough based on whole grain barley and amaranth flour, the process of moisture release during baking began faster, since the boiling point of their suspension was 7–7.5% lower than that of other types of flour. This predicted a reduction in the baking time of cookies.

Thus, the conducted studies determined the difference in quality indicators of millet whole grain flour from the highgrade flour, and also clarified the differences in quality indicators of different types of flour. The negative effect of millet whole grain flour on the formation of the structure of the dough for cookies and, accordingly, the consistency of the finished product was confirmed. In order to adjust the structure of the dough, and, accordingly, the consistency of the finished product, the introduction of enzyme preparations of the hydrolytic direction was proposed. Glucoamylase enzymes for the hydrolytic breakdown of flour starch, and cellulase for the hydrolytic breakdown of cellulose and its derivatives were used. Enzymes were added to the model system of flour and water separately and in combination. The results of glucose accumulation, as the main hydrolysis product, are shown in Figure 3.

It was found that the addition of enzyme preparations contributed to the accumulation of glucose, which led to an increase in the proportion of water-soluble compounds and improved the consistency of the dough. Thus, the addition of glucoamylase to whole grain wheat dough increased the amount of glucose 4.1 times during 6 hours, from spelt flour – 4.43 times, based on barley flour – 3.72 times, from amaranth flour – 9.2 times, from green buckwheat – 12.1 times.

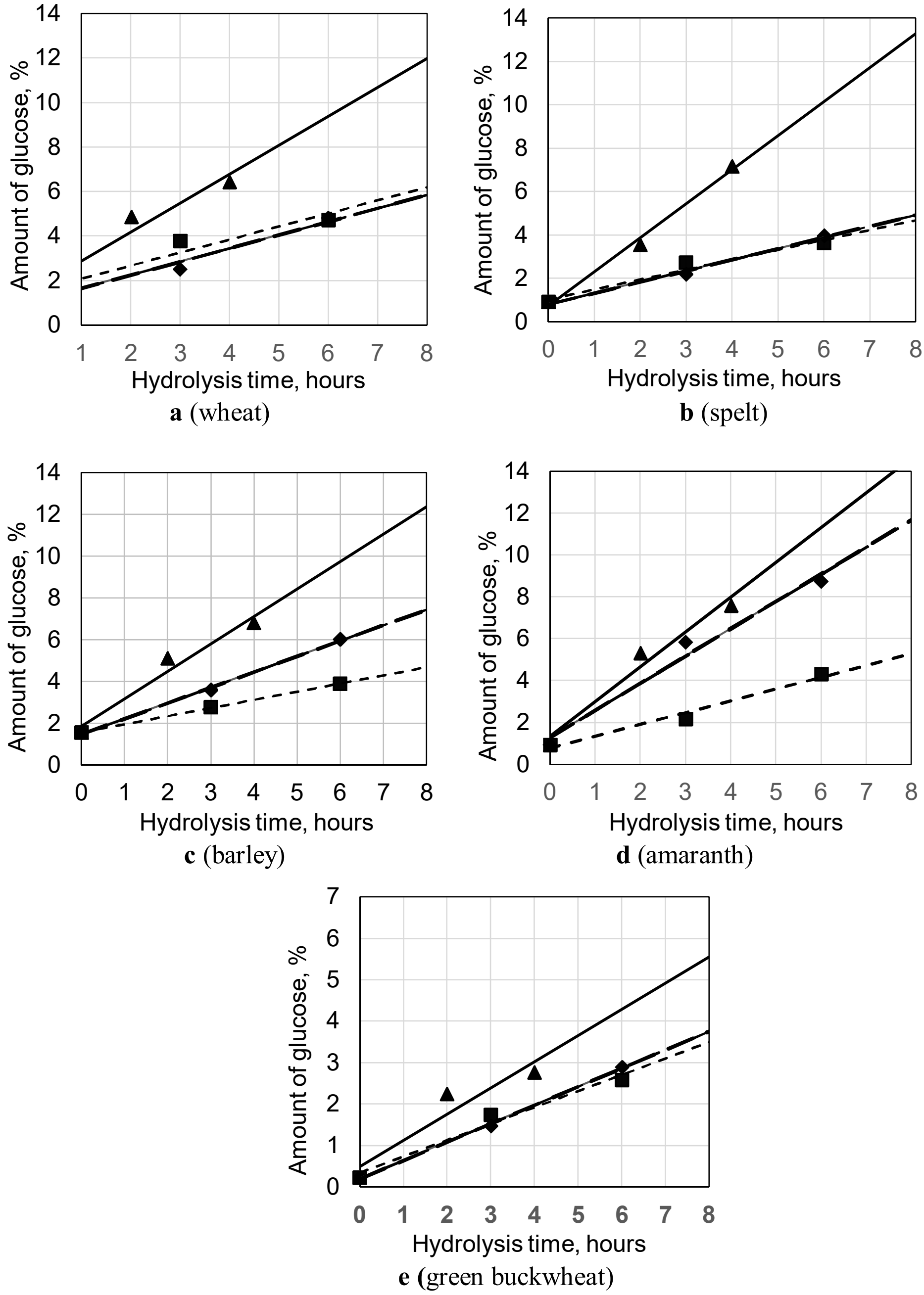

Figure 3. Enzymatic hydrolysis of whole grain flour under the influence of:

amylase;

cellulases;

amylase and cellulase complex

a) wheat; b) spelt; c) barley; d) amaranth; e) green buckwheat

The process of enzymatic hydrolysis of starch, with a smaller amount of glucoamylase used, occured faster compared to cellulose hydrolysis. That is, the flexibility of starch grains, the presence of grains damaged during the grinding process, determined better availability of the substrate and attack by the enzyme. Thus, during 6 hours of fermentation for a sample with wheat flour under the action of cellulase, 1.15% less glucose accumulated than under the action of glucoamylase, for a sample with spelt – by 9.27%, for a sample with barley – by 28.4%, with amaranth – by 50.7%, with green buckwheat flour – by 10.3%;

The combined use of enzymes sped up the process and improved the consistency of the dough, which led to a reduction in the fermentation process. Thus, for samples with wheat flour with the joint introduction of enzymes, the amount of glucose accumulated during 6 hours from the single introduction of enzymes was achieved after 2 hours. Practically the same was observed for samples with spelt flour. For samples with barley flour – in 3 hours, with green buckwheat flour – in 4 hours, with amaranth flour – in 4.5 hours. This result will have a significant impact on the technological process of producing cookies with whole grain flour and will allow adjusting the dough proofing time in the fermentation chamber.

Conclusions

1. Whole grain flour had sensory characteristics that corresponded to the specific characteristics of the grain and in terms of appearance, taste, smell and color, it was significantly different from high grade wheat flour. Spelt and barley flour were lighter in whiteness, and wheat and amaranth were the darkest.
2. The granulometric composition of millet whole grain flour was not homogeneous. The main fraction of each type of whole grain flour was larger than high grade wheat flour. The size of the main fraction of particles of whole grain amaranth and wheat flour varied in the range of 150–200 microns, green buckwheat flour and barley flour – >200 microns and 132–150 microns, spelt flour – 150–670 microns.
3. Among the studied types of flour, the gluten complex formed only in whole grain wheat and spelt flour. At the same time, the amount of washed gluten in whole grain wheat flour was 34.5% less than in high grade wheat flour, and in whole grain spelt flour – 24.5% less.
4. The studied types of flour had an individual structure of starch grains: amaranth and barley flour were characterized by small ones, green buckwheat flour was characterized by large starch grains of polygonal shape, and wheat and spelt flour starch grains were characterized by a round or oval shape of medium size.
5. The structure of the dough with whole grain flour did not correspond to the viscous-plastic characteristics of cookies, but can be improved by adding enzyme preparations of hydrolytic action. It was determined that the introduction of glucoamylase and cellulase provided an increase in the glucose level in the dough, thereby increasing the amount of water-soluble compounds and improving the consistency. The best result was obtained with the joint introduction of enzymes, when the fermentation time was reduced by 2–4 hours compared to their single introduction.

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